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Traders' heterogeneity and bubble-crash patterns in experimental asset markets☆

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ABSTRACT

We propose a heterogeneous agent model for experimental closed-book call markets with speculators, fundamental and noise traders. We provide structural estimates of the parameters of the model using new experimental data, which allow us to track individual behavior, cognitive reflection abilities, and accuracy of price forecasts. Based on the model's predictions for individual behavior we identify different types of traders in the data. We find that fundamental traders and speculators have higher terminal wealth and perform better on a cognitive reflection test and price forecasting than noise traders. More importantly, we find that all three types of traders are important to understand the mechanics of bubbles and crashes. In the initial period, fundamental traders buy from noise traders. Next, speculators buy from fundamental traders during the boom. Finally, speculators generate the crash by selling to noise traders. Our model predicts smaller bubbles if the cash and asset endowments are higher, keeping the cash-to-asset ratio constant. Our theory has predictive power as we confirm this prediction with additional out-of-sample data.

1. Introduction

There are several examples of bubbles: the Dutch tulip mania (1634–1637), the South Sea Company Bubble (1720), the Roaring Twenties stock-market bubble (1922–1929), the Dot-com bubble (1995–2000) and more recently, real-estate bubbles in the US as well as Europe and China. Bubbles generate price distortions that may lead to allocative inefficiencies and financial crises. Bubbles are a complex phenomenon, attracting economists to use theoretical models and empirical methods to study them. Laboratory experiments provide a useful tool to study bubbles empirically since they allow economists to control a variety of factors that are difficult to control in field environments (e.g., trading institutions, the fundamental value process and the dividend process).

Bubbles and crashes in experimental asset markets were first documented by Smith et al. (1988) (SSW) and proved to be a very robust result in experimental economics.[1] Bubbles are attributed to a combination of factors including speculation,

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[1] The bubble-crash pattern persists in treatments with capital gains taxes, no short-selling constraints, transaction fees or the use of a sophisticated subject pool such as corporate managers, professional stock traders, etc. (King et al., 1993; Lei et al., 2001). Experience of traders in a stationary environment is

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subject confusion, lack of common knowledge of rationality and lack of rationality (e.g., Smith et al., 1988, 2000; Lei et al., 2001; Caginalp and Ilieva, 2005; Ackert and Kluger, 2006; Haruvy and Noussair, 2006; Kirchler et al., 2012; Moinas and Pouget, 2013; Akiyama et al., 2013; Cheung et al., 2014).[2] Generally, a clear understanding of the mechanics of bubble formation is still missing. For instance, we do not have many models that help us to understand when and why bubbles start and crash (Brunnermeier, 2008).

In this paper we propose an explanatory theory based on a heterogeneous agent model which sheds light on the mechanics of bubble formation in experimental closed-book call markets and we provide evidence for its predictive power.[3] We also collect new experimental data, which allow us to track individual behavior and to control for cognitive reflection abilities of subjects.

While the Smith et al. (1988) laboratory environment is much simpler than field asset markets, we think it can shed light on behavior in field markets. Existing experimental studies provide support for the existence of speculative and other behavioral biases among traders in laboratory asset markets (e.g., Smith et al., 1988; Lei et al., 2001; Caginalp and Ilieva, 2005; Haruvy and Noussair, 2006). These biases are also present in field markets and are conjectured to contribute to bubble formation more generally. Specifically, there is evidence that heterogeneous strategies and different levels of traders' sophistication in actual markets may contribute to bubbles' formation (e.g., DeLong et al., 1990a; Griffin et al., 2011). Furthermore, the Smith et al. (1988) environment is the prominent paradigm for the study of bubbles and factors affecting bubble formation in long-lived experimental asset markets. Many laboratory studies focus on this environment, but, due to the complexity of the environment, theoretical modeling has not been developed (with a couple of exceptions, e.g., Duffy and Ünver, 2006; Haruvy and Noussair, 2006).

In this paper, we formalize behavioral biases that we believe play an important role in bubble formation. There are three classes of agents in the model: noise traders, fundamental traders and speculators. Our traders' types are similar in spirit to the types introduced by DeLong et al. (1990a). However, the novelty of our approach is that we model traders' types differently in order to account for the laboratory environment and to match the trading volume dynamics in addition to the price dynamics of the experimental data. Along the lines of Duffy and Ünver (2006), noise traders are equally likely to be either buyers or sellers in each period, and their bid/ask price is determined by the previous period clearing price and a noise term.[4] Fundamental traders tend to buy when the price is below and tend to sell when the price is above the fundamental value, forming price expectations adaptively. Speculators form their price expectations taking into account the presence of noise traders in the spirit of Level-1 traders. They buy when the price is expected to increase and sell otherwise, i.e., their trading behavior is motivated by potential capital gains.[5]

We provide structural estimates of the parameters of the model using new experimental data on five closed-book call-market sessions. New features of the data that are important for our study include individual behavior's records, and the elicitation of cognitive reflection abilities and accuracy of price forecasts. Individual behavior's records allow us to identify different traders' types in the data (via the model), while cognitive reflection abilities and price forecast accuracy provide additional support for our identification strategy. The estimation is conducted by fitting aggregate simulated variables – prices and volume – to the corresponding aggregate experimental variables. According to the estimation, 11% of subjects are speculators, 44% of subjects are fundamental traders and the remaining subjects are noise traders. We show that simulated fundamental traders accumulate assets early and sell their units gradually to speculators and noise traders. Speculators accumulate a substantial number of assets during the boom and initiate the crash. Simulated fundamental traders and speculators end up with much lower asset holdings (close to zero) than noise traders. Speculators end up with the highest simulated terminal wealth levels, followed by fundamental traders. Noise traders end up with significantly lower wealth levels.

Next we use the simulated trading strategies and individual asset holdings data to identify trader types at a micro-level. The validity of our classification is also supported by individual characteristics of subjects (forecasts accuracy and cognitive reflection test scores) which were not used in the estimation. In particular, fundamental traders are much better in predicting the first-period price than other types, and noise traders are worse in price forecasting during the crash compared

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one of the major factors which dampens or eliminates bubbles under the SSW design (Smith et al., 1988; Porter and Smith, 1995; Dufwenberg et al., 2005; Hussam et al., 2008)

[2] For instance, Lei et al. (2001) show that even if capital gains are not possible, the standard bubble-crash pattern persists. Lei and Vesely (2009) show that a pre-trading period before the actual asset market experiment starts, designed to decrease subject confusion about the stochastic dividend process, entirely eliminates the bubble-crash pattern. Smith et al. (2000) show that if dividends are paid at the end of the trading horizon only (the least confusing design) the formation of bubbles is least likely. Kirchler et al. (2012) and Huber and Kirchler (2012) show that the main source for subject-confusion is the decreasing fundamental value process. However, Noussair et al. (2001), Noussair and Tucker (2014) and Baghestanian and Walker (2014) show that bubbles emerge also in environments with flat fundamental value. Other studies suggest that while confusion plays a role in the formation of bubbles and mispricing, strategic uncertainty and the lack of common expectations also play an important role, e.g., Akiyama et al. (2013) and Cheung et al. (2014).

[3] For more details on explanatory and predictive theories, see Schotter (2009).

[4] Note that noise traders in our model differ from Duffy and Ünver near-zero-intelligence traders in that we do not assume that noise traders have weak foresight. The assumption of weak foresight is important for Duffy and Ünver (2006) to generate the observed crash-patterns in the lab since they only have one type of traders.

[5] We elaborate below that speculators are similar to Level-1 trader types, characterized by one step of iterated reasoning in their expectation formation (Stahl and Wilson, 1994, 1995; Costa-Gomes and Crawford, 2006; Crawford et al., 2013). In accordance with the Level-*k* literature we impose that their anchoring types (commonly referred to as L_0-type) are noise traders.